1.8.3 Ground Water

The approximate groundwater level is at 613 M.S.L. which is approximately 6 feet below the approximate existing ground surface level of 619 M.S.L. This groundwater table is a true groundwater table. Clay fines will need to be added to the S-B slurry wall construction as cohesionless fine sand soils encountered at the site do not exhibit the necessary 20%-40% passing by dry weight for the slurry wall as shown in the gradation requirements in paragraph 2.1.3 backfill material of this section.

1.9 QUALITY CONTROL TESTING

The Contractor shall provide Quality Control Inspectors as necessary for bentonite slurry preparation and maintenance, trench excavation, and S-B backfill preparation and placement.

1.9.1 Bentonite Tests

A minimum of 1 test for each specified requirement shall be performed for each truck or rail car shipment delivered to the site.

1.9.2 Water Tests

A minimum of test 1 for each specified requirement shall be performed for each water source used. Testing shall be performed as specified in Table 1.

1.9.3 Backfill Material Tests

One set of backfill material tests, as specified in Table 1, shall be performed for every 500 cubic yards used.

1.9.4 Slurry Properties

Slurry shall be required to hydrate a minimum of 8 hours prior to use. The initial bentonite slurry shall be tested prior to placing in the trench and a minimum of 2 times each 8 hour shift per mixing plant.

1.9.5 S-B Backfill Tests

Sampling and testing shall be performed, in accordance with the approved Preconstruction Testing Plan, just prior to placing S-B backfill in the trench as shown in Table 1. The density of the S-B backfill shall be calculated using a 4 inch cylindrical mold as described in Paragraph 6 of ASTM D 698. S-B backfill shall be placed in the mold and rodded 10 times. Additional S-B backfill shall then be added to fill the mold. The weight and volume of the molded S-B backfill shall then be used to determine the density. The density of the S-B backfill shall be determined using a mud balance. Density shall be determined at a rate of 1 test for every 1000 cubic yards. A sample of S-B backfill for permeability testing shall be taken just prior to placement in the trench for every 1000 cubic yards. The Contractor shall submit an S-B Backfill Test Report containing the results of the tests performed.

1.9.6 Samples of Confining Stratum

Samples of the confining stratum shall be taken at 20 foot
horizontal intervals and at additional intervals or depths as directed by the Engineer. Samples shall be obtained from excavator bucket cuttings or drive samplers. The drive sampler shall be a 1.75 inch I.D., or larger, shall be obtained by advancing the sampler a minimum of 24 inches into the confining stratum. The sample shall have a minimum length recovery of 12 inches.

After examining these samples, the on site Geotechnical Engineer will either approve the termination of excavation at the sample points or require additional excavation. If additional excavation is required, then additional samples shall be furnished by the Contractor as specified above. All samples shall be properly identified and labeled, placed in sealed plastic containers and stored in a location designated by the Geotechnical Engineer.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Bentonite

The bentonite shall be sodium cation base montmorillonite powder that conforms to API Spec 13A, Section 5, and Table 1, located at the end of this section. No bentonite from the bentonite manufacturer shall be used prior to acceptance by the Engineer. Bentonite not meeting specifications shall be promptly removed from the site at the Contractors expense. Bentonite shall be protected from moisture during transit and storage.

2.1.2 Water

The Contractor shall supply and condition water required for mixing with bentonite to produce slurry. The water shall be clean, fresh, and comply with the standards specified in Table 1. The Contractor shall furnish water quality test results for water used for mixing the bentonite slurry to assure conformance to these standards.

2.1.3 Backfill Material

The backfill material shall be obtained from an offsite borrow area. Thirty days prior to utilization of any off-site borrow, the site shall be identified and representative samples of each type of material shall be submitted to the Engineer for QA testing. Backfill shall be free of contamination, roots, debris, brush, sod, organic or frozen material. Material passing the 75 micrometer No. 200 sieve shall have a liquid limit greater than 30 and a plasticity index greater than 10. Materials shall be thoroughly blended prior to mixing with bentonite slurry and shall conform to the following gradation requirements above:

Screen Size or Number (U.S. Standard)	Percent Passing by Dry Weight
3 inch	100
No. 4	40-80
No. 40	25-60
No. 200	20-40

Clay fines obtained from an off-site source and approved by the Engineer will need to be added to the soil bentonite (S-B) slurry wall as in-situ cohesionless fine sand soils encountered in the upper 25 to 35 feet of the project site do not exhibit the necessary 20%-40% passing by dry weight for the slurry wall as shown in the gradation requirements.

2.2 EQUIPMENT

The Contractor shall furnish all necessary plant and equipment for use on this project.

2.2.1 Trench Excavation Equipment

Equipment for excavating the slurry trench shall be any type or combination of excavating equipment capable of performing the work as specified and shown on the drawings. The equipment shall be capable of excavating the required minimum width of trench in a single pass of the excavating equipment. The buckets utilized with such equipment may be perforated, tapered and equipped with bottom-side cutter teeth protruding no more than 6 inches. The bucket shall be designed to maintain the width of the trench and to minimize ravelling of the trench sides during use. The equipment shall be able to reach at least 5 feet deeper than the maximum depth shown on the drawings.

2.2.2 Slurry Mixing and Cleaning Equipment

The slurry mixing plant shall be equipped with a high-speed/high-shear, colloidal mixer or a high-velocity/high pressure venturi jet mixer used in conjunction with a high-speed/high-shear centrifugal pump. The plant shall be equipped with a mechanically or hydraulically agitated sump and shall include pumps, valves, hoses, supply lines, tools, and other equipment and materials required to prepare the slurry and deliver it in a continuous supply from the mixing pond or tanks to the slurry trench. Mixers shall be capable of achieving complete dispersion of bentonite and additives, and shall be capable of continually mixing the slurry to provide and maintain a uniform blended slurry. The Contractor shall have sufficient ponds or tanks for storage of hydrated bentonite slurry. Slurry cleaning equipment shall be available to reduce sand, sediment, or other solids as necessary to maintain the sand content or density requirements of the slurry in the trench. Slurry cleaning equipment may include but not be limited to vibratory shaker screens, centrifugal sand separators, or stilling ponds.

2.2.3 Field Laboratory Equipment

The field laboratory shall contain as a minimum the following equipment:

a. 1 Mold and rod for slump test.
b. 2 Marsh funnel sets.
c. 1 Standard filter press.
d. 2 Mud balances (direct reading of density).
e. 1 Slurry sampler.
f. 2 Number 200 sieves.
g. 1 Set of standard sieves and sieve shaker.
h. 1 Oven for moisture content.
i. 1 Balance.
j. 1 pH meter or pH paper.
k. 2 Sand content sets.
l. 1 101.6 mm 4 inch Cylindrical mold.

2.3 BENTONITE SLURRY MIXES

2.3.1 Initial Bentonite Slurry Mixture

The initial bentonite slurry mixture shall conform to the standards specified in Table 1.

2.3.2 Trench Bentonite Slurry Mixture

The trench bentonite slurry mixture shall conform to the standards specified in Table 1.

2.3.3 Additional Bentonite

If directed by the Engineer, the Contractor shall thicken the slurry to a more viscous condition than the limits specified above. The Contractor shall use additional bentonite, as directed.

2.3.4 Additives

Peptizing agents and bulking agents shall not be mixed with the slurry. Approved thinners or dispersants and flocculants of the types used in the control of oil field drilling muds, may be used to control standard properties of the slurry such as apparent viscosity, pH and filtration characteristics.

2.3.5 S-B Backfill

The S-B backfill, consisting of backfill material and bentonite slurry shall be thoroughly mixed and shall conform to the standards specified in Table 1 just prior to placement in the trench.

PART 3 EXECUTION

3.1 GENERAL

The slurry trench shall be constructed to the elevations, lines, grades, and cross-sections shown on the plans and in accordance with these specifications, unless otherwise directed. The Engineer may modify the dimensions and quantities of the work as determined necessary. The Contractor shall submit a Slurry Trench Implementation Plan for approval, a minimum of 4 weeks prior to the start of construction.

3.2 WORKING SURFACE

Slurry trench construction shall be accomplished from the working surface as shown on the drawings. If the Contractor's operations require a wider working surface, the reason for the change shall be submitted. If approved, a wider working surface may be constructed at no additional cost to the Engineer. In the event that the static ground water table is encountered at a depth of 3.0 foot or less below the designated working surface, the Contractor shall, at the direction of the Engineer, raise the working surface to a height of 3 feet above the measured static ground water level with approved fill material. The working surface thus constructed shall be utilized as a basis for measurement for payment.

3.3 SLURRY TRENCH EXCAVATION

The excavation shall begin from the working surface and shall provide a vertical (within 2 percent) continuous 3 foot minimum width trench to the required depth along the centerline of the excavation. The slurry trench shall key approximately 2 feet into the dense to very dense gray silt to silty loam stratum. The Geotechnical Engineer may direct the Contractor to modify the trench depth based on examination of bucket cuttings or drive samples. The toe of the slope of the trench excavation shall not precede the toe of the S-B backfill slope by more than 30 feet. At the intersection of 2 straight line segments, the trench excavation shall extend a minimum of 5 feet beyond the outside of the intersection at all depths. If trench excavation overlaps into previously completed slurry trench, the excavation shall extend a minimum of 10 feet into the previously placed S-B backfill at all depths. Any removed section of completed slurry trench shall be refilled with S-B backfill at no additional expense to the Engineer.

3.3.1 Confining Stratum Excavation

The confining stratum shall be excavated the full trench width to the depths/elevations shown on the plans or to the depth of refusal as determined by the Geotechnical Engineer on site. The

confining stratum shall then be sampled in accordance with paragraph SAMPLES OF CONFINING STRATUM. Termination of excavation will be approved by the Engineer.

3.4 SLURRY PLACEMENT AND TESTING

3.4.1 Slurry Placement

Slurry shall be introduced into the trench at the time excavation begins. The level of the slurry in open trenches shall be maintained a minimum of 3 feet above ground water level and no more than 2 feet below the top of the working surface until the placement of S-B backfill is complete. If the density or sand content of the slurry in the trench does not conform to the standards specified in Table 1, the excess solids shall be removed from the slurry using approved methods or the slurry shall be replaced with fresh slurry. Slurry shall not be diluted by surface water. Conditioning of the slurry may require recirculation through a shaker screen or the addition of approved additives. The Contractor shall have sufficient personnel, equipment, slurry storage areas, and prepared slurry materials shall be ready to raise the slurry level at any time in the excavated trench, weekends and holidays included.

3.4.2 Slurry Testing

The bentonite slurry in the trench shall be sampled a minimum of 2 times each 8 hour shift (near the beginning and end of each shift), at two depths; approximately 2 feet below the slurry surface and approximately 2 feet above the bottom of the trench. These samples shall be taken within 5 feet of the toe of the S-B backfill slope. Additional samples shall be obtained at the request of the Engineer.

3.5 EXCAVATED MATERIAL

Material excavated from the trench shall not be used as backfill. Excavated trench material not used as backfill shall be placed as directed by the Engineer to an off-site legal disposal area.

3.6 STABILITY

The Contractor shall be responsible for insuring and maintaining the stability of the excavated trench at all times for its full length and depth and shall be responsible for maintaining slurry densities and levels within specified limits. The Contractor shall control surcharges from all excavation and backfilling equipment, waste, berm construction, backfill stockpiles, and any other loading situations that may affect trench stability. It is the Contractor's sole responsibility to ensure that the mixing of S-B backfill and any stockpiles do not affect the open trench stability. In the event of failure of the trench walls prior to completion of backfilling, the Contractor shall at his expense re-excavate the trench and remove all material displaced into the trench and take corrective action to prevent further deterioration.

3.6.1 Backfill of 24" Force Main and 42" Concrete Pipe Through the Slurry Wall

The locations where the completed slurry trench cutoff wall is to be crossed by the 24 inch diameter ductile iron force main from the stormwater pumping station and by a 42 inch diameter concrete storm water pipe from the north central side of the detention basin will have to be dewatered outside of the slurry wall. The pipe should be placed in either a sheeted trench excavation or stacked trench box excavation through the slurry wall with both the bedding and backfill being approved compacted silty clay fill (meeting the requirements for the compacted clay liner in Section 2350) placed and compacted under and around and over the pipe the entire trench depth and width in 8 inch loose lifts to the

minimum compaction requirements given in section 02350 for the compacted clay liner (CCL). This compacted clay fill placed to the width and depth as stated previously shall be placed approximately 10 feet from the center of the slurry wall in a direction away from the pond and also 10 feet from the center of the slurry wall in the direction toward the pond. (See project plans)

3.7 TRENCH CLEANING

At a minimum, unless otherwise approved, the trench bottom shall be cleaned at the start of each day. If S-B backfill placement operations have ceased for longer than 24 hours, the face of the S-B backfill slope shall be cleaned prior to the placement of additional S-B backfill. The trench bottom shall be probed for any deposits or sloughed materials prior to cleaning. The trench bottom shall be cleaned by using an excavator bucket, or other approved equipment to ensure removal of sand, gravel, sediment, and other material left in the trench during excavation or which has settled out of the slurry. Cleaning equipment shall not remove material from the walls of the trench. The Engineer may require more frequent cleaning.

After the trench bottom has been cleaned, the contractor shall sample the trench bottom with a drive sampler approved by the Engineer. After examining the samples, the Engineer will either approve the excavation at the points checked or require additional cleaning. If additional cleaning is required, then additional samples shall be furnished by the Contractor as specified above.

3.8 S-B BACKFILL MIXING AND PLACEMENT

3.8.1 Mixing

The S-B backfill shall be thoroughly mixed via disking, harrowing, bulldozing, blading, or other approved methods into a homogeneous mass, free from large lumps or clods of soil or pockets of fines, sand, or gravel. Occasional lumps of up to 3 inches in their largest dimension will be permitted. All particles shall be coated with slurry. The S-B backfill may be sluiced with slurry during the mixing operations. Sluicing with water is not permitted. The S-B backfill shall be mixed along the side of the trench. When mixing the S-B backfill along the side of the trench, heavy equipment such as bulldozers shall not operate in a back and forth fashion, paralleling the open trench, closer than 15 feet from the lip of the trench. Excess slurry may be allowed to flow back into the trench.

3.8.2 Placement

Initial S-B backfill placement shall be by one of the following methods: (1) Placement by lowering S-B slurry to the bottom of the trench with crane and clamshell bucket, or tremie methods until the surface of the S-B backfill rises above the surface of the slurry trench at the end of the trench; (2) Construct a lead-in trench 1H:1V or flatter at a point outside of the limits of work to allow a S-B backfill face to form prior to reaching the full depth of the required slurry trench. No payments will be made for the portions of trenches which lie outside of the limits of work. Placement operations shall proceed in such a manner that the slope of the initially placed S-B backfill is maintained. Free dropping of S-B backfill through the slurry is not permitted. The S-B backfill shall be placed so that it will slide down the forward face of the S-B backfill slope. The S-B backfill shall be placed in the excavated trench so that no pockets of slurry are trapped and that a constant slope is maintained. Placement shall be continuous from the beginning of the trench in the direction of the excavation to the end of the trench.

3.8.3 Mixing and Placing During Cold Weather

No mixing or placing of the S-B backfill shall be performed when the air temperature is below -7 degrees C 20 degrees F. Frozen S-B backfill shall not be placed in the trench and backfill material containing frozen lumps shall not be used to mix S-B backfill.

3.8.4 Testing

When required, additional samples for permeability testing shall be taken at 5 feet intervals for the full depths of the completed slurry trench using 3 inch thin wall (Shelby) tubes. If test results do not meet the requirements listed in Table 1, corrective action, as determined by the Engineer, shall be taken.

3.9 SOUNDINGS

Excavation and S-B backfill soundings shall be taken every 20 feet along the trench centerline using a weighted tape, cable, or other approved device. Soundings shall be measured to the nearest 0.1 ft. The soundings shall measure the following:

3.9.1 Elevation of Top of Confining Stratum

The top of the confining stratum shall be determined based on examination of samples taken as described under paragraph SAMPLES OF CONFINING STRATUM. This elevation shall be subject to approval.

3.9.2 Elevation of Trench Bottom Prior to Backfilling

The Contractor shall determine the elevation of the trench bottom after the trench has been cleaned and approved as described under paragraph Trench Cleaning. This sounding shall not precede the toe of the S-B backfill slope more than 50 feet. This elevation is subject to approval by the Engineer.

3.9.3 Profile of S-B Backfill Slope and Trench Bottom

The S-B backfill slope and trench bottom shall be sounded at the beginning and end of each shift, and at additional times as directed, at intervals of 50 feet.

3.10 AS-BUILT PROFILE

An as-built profile of the trench bottom and S-B backfill slopes, including descriptions of materials encountered in the trench bottom, shall be continuously maintained. This profile shall indicate extent of excavation and the S-B backfill profile at the end of each work day and after each S-B backfill batch is placed in the trench as determined from soundings. The S-B backfill batch numbers shall appear on the profile with the limits of each batch of material delineated as placed.

3.11 TREATMENT OF TOP OF SLURRY TRENCH

Prior to placement of the compacted trench cover, a temporary
non-compacted soil cover shall be placed over the trench to prevent desiccation. The temporary cover material shall be placed within 2 days after S-B backfill placement is completed over each 100 foot reach. If any depression develops within the completed slurry trench area, it shall be repaired by placing and compacting additional trench cover soil. After a minimum 2 weeks, the temporary trench cover shall be removed and replaced by a final compacted clay liner. The final compacted trench cover shall consist of both a minimum of 20 inches of approved compacted clay liner (CCL) placed directly over the top of the slurry wall on flat areas and a minimum of 1 foot of approved compacted clay liner placed directly over the top of the slurry wall on sloped areas as shown on the project plans and meeting the requirements in Section 02350 of the specifications. The compacted clay liner 3 feet wide and 20 inches deep (placed over the tops of slurry walls on proposed flat areas—typical) or 1 foot deep (placed over the tops of slurry walls

located on the north sloped area of the pond as shown on plans) shall be placed and compacted according to the requirements given in Section 02350. Four (4) inches of approved topsoil shall then be placed over the compacted clay liner according to the requirements given in section 02350 of the specifications. Heavy construction equipment and machinery shall only be driven over the slurry trench at approved heavy equipment crossing points with a minimum of 3 feet of compacted clay cover.

3.12 CLEAN-UP

Excavation spoil, unused S-B backfill, and excess slurry shall be removed following completion of S-B backfill placement. These materials shall be disposed of at the direction of the Contractor and legally disposed off-site.

TABLE 1
SOIL-BENTONITE SLURRY TRENCH QUALITY CONTROL TESTING

Property	Requirement	Test Method
	Bentonite Powder	
a. YP/PV Ratio	1.5 max.	API Spec 13A
b. Plastic Viscosity	> 10	API Spec 13A
c. Filtrate Loss	< 12.5 cubic cm	API Spec 13A
d. Moisture Content	< 10%	ASTM D 2216
	Chemical Analysis of Water	
a. pH	6 to 8	API RP 13B-1
b. Hardness	< 50 ppm	API RP 13B-1
c. Total Dissolved Solids	< 500 ppm	EPA 600/4-79/020 Method 160.1
d. VOCs	MCL	SW-846 Method 5030B/8260B]
e. SVOCs	MCL	SW-846 Method 3510C/8270C]
f. TPH	MCL	SW-846 Modified 8015]
g. Metals	MCL	SW-846 3005A/6010C]
h. Pesticides	MCL	SW-846 3510C/8081A/8141A]
	Initial Bentonite Slurry	
a. Viscosity	> 40 sec	API RP 13B-1
b. Density	> 1025 kg/cubic m	API RP 13B-1
c. Filtrate Loss	< 20 cubic cm	API RP 13B-1
d. pH	6.5 to 10	API RP 13B-1
	In-Trench Bentonite Slurry	
a. Density	1025-1360 kg/cubic m and at least 240 kg/cubic m less than S-B backfill density	API RP 13B-1
b. Viscosity	> 40 sec	API RP 13B-1
c. pH	6.5 to 10	API RP 13B-1
d. Sand Content	10% max.	API RP 13B-1]

MCL = Maximum Contaminant Level

TABLE 1
SOIL-BENTONITE SLURRY TRENCH QUALITY CONTROL TESTING

Property	Requirement	Test Method
	Backfill Material	
a. Grain Size	Para. 2.1.3	ASTM D 422
b. Moisture content	For record	ASTM D 2216
c. Fines Content	Para. 2.1.3	ASTM D 1140
d. Atterberg limits	Para. 2.1.3	ASTM D 4318
	S-B Backfill	
a. Slump Cone	100-150 mm	ASTM C 143/C 143M
b. Density	For Record	ASTM D 698 and Para. 2.4.52
c. Permeability	< 1 x 10-7 cm/sec	ASTM D 2434 ASTM D 5084
	Bentonite Powder	
a. YP/PV Ratio	1.5 maximum	API Spec 13A
b. Plastic Viscosity	> 10	API Spec 13A
c. Filtrate Loss	< 12.5 cubic cm	API Spec 13A
d. Moisture Content	< 10%	ASTM D 2216
	Chemical Analysis of Water	
a. pH	6 to 8	API RP 13B-1
b. Hardness	< 50 ppm	API RP 13B-1
c. Total Dissolved Solids	< 500 ppm	EPA 600/4-79/020 Method 160.1
d. VOCs	MCL	SW-846 Method 5030B/8260B]
e. SVOCs	MCL	SW-846 Method 3510C/8270C]
f. TPH	MCL	SW-846 Modified 8015]
g. Metals	MCL	SW-846 3005A/6010C]
h. Pesticides	MCL	SW-846 3510C/8081A/8141A]

MCL = Maximum Contaminant Level

TABLE 1
SOIL-BENTONITE SLURRY TRENCH QUALITY CONTROL TESTING

Property	Requirement	Test Method
	Initial Bentonite Slurry	
a. Viscosity	> 40 sec	API RP 13B-1
b. Density	> 64 pcf	API RP 13B-1
c. Filtrate Loss	< 20 cubic cm	API RP 13B-1
d. pH	6.5 to 10	API RP 13B-1
	In-Trench Bentonite Slurry	
a. Density	64-85 pcf and at least 15 pcf less than S-B backfill density	API RP 13B-1
b. Viscosity	> 40 sec	API RP 13B-1
c. pH	6.5 to 10	API RP 13B-1
d. Sand Content	10% max	API RP 13B-1
	Backfill Material	
a. Grain Size	Para. 2.1.3	ASTM D 422
b. Moisture content	For record	ASTM D 2216
c. Fines Content	Para. 2.1.3	ASTM D 1140
d. Atterberg limits	Para. 2.1.3 S-B Backfill	ASTM D 4318]
a. Slump Cone	4-6 inches	ASTM C 143/C 143M
b. Density	For Record	ASTM D 698 and Para. 2.4.5
c. Permeability	< 1 x 10-7 cm/sec	ASTM D 2434 ASTM D 5084

NOTES:

1) If more than one (1) batching plant is being used, these frequencies shall apply to each batching plant separately.

2) Permeability tests may be performed using an approved fixed wall permeameter except that for every 5 such tests, there shall be 1 test using a flexible wall permeameter. Fixed wall test methods and procedures shall be submitted and approved prior to use.

3) Flexible wall permeability tests shall be performed at a maximum effective confining pressure of 15 psi and a maximum hydraulic gradient of 30.

SECTION 02350
IMPORTED NATURAL COMPACTED CLAY LINER
(CCL) FOR DETENTION POND

PART 1 GENERAL

1.1 REFERENCES

1.2 PAYMENT

1.2.1 Placement of Approved Off Site Clay Borrow

1.2.2 Placement of Approved Topsoil

1.3 DEFINITIONS

1.3.1 Satisfactory Materials

1.3.1.2 Imported Natural Clay for Pond Liner

1.3.1.2 Topsoil

1.3.2 Unsatisfactory Materials

1.4 SUBMITTALS

PART 2 EXECUTION

2.1 OFF-SITE CLAY BORROW APPROVAL

2.1.1 Minimum Percent Compaction of the Natural Imported Clay Liner

2.1.1.1 Natural Imported Compacted Clay Along Pond/Structure Interface

2.1.1.2 Compacted Clay Liner Against Slurry Wall Exterior

2.1.2 Minimum Compaction of the Topsoil Layer

2.1.3 Placement of Compacted Clay Liner and Compacted Topsoil Layer

2.1.4 Seeding

2.1.5 Cost of Geotechnical Testing

3.1 ON SITE GEOTECHNICAL ENGINEER

SECTION 02350
IMPORTED NATURAL COMPACTED CLAY LINER
(CCL) FOR DETENTION POND

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO T 180	(2001) Moisture-Density Relations of Soils Using a 4.54-kg (10-1b) Rammer and an 457-mm (18-in) Drop

ASTM INTERNATIONAL (ASTM)

ASTM D 1140	(2000) Amount of Material in Soils Finer than the No. 200 (75-micrometer) Sieve
ASTM D 1557	(2002) Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/cu. ft.)
ASTM D 2487	(2000) Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D 2922	(2001) Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shall Depth)
ASTM D 3017	(2001) Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)
ASTM D 422	(1963; R 2002) Particle-Size Analysis of Soils
ASTM D 4318	(2000) Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D 698	(2000) Test Method for Laboratory Compaction Characteristics of Soils Using Standard Effort (12,400 ft-lbf/cu. ft.)

1.2 PAYMENT

1.2.1 Placement of Approved Off-Site Clay Borrow

The in-place compacted volume of the approved clay borrow meeting the requirements given in this Section obtained from off site for the proposed detention pond will be paid for at the contract unit price per CUBIC YARD for COMPACTED CLAY LAYER.

1.2.2 Placement of Approved Topsoil

The in-place compacted volume of approved topsoil will be paid for at the contract unit price per CUBIC YARD for TOPSOIL FURNISH AND PLACE, SPECIAL.

1.3 DEFINITIONS

1.3.1 Satisfactory Materials

1.3.1.1 Imported Natural Clay for Pond Liner.

The maximum coefficient of permeability of the compacted clay soils for the CCL pond liner should be 1×10^{-7} cm/sec or less, per USEPA and IEPA criteria. The compacted clay liner material should have the following soil properties:

1. Percent finer than #200 sieve greater than or equal to 50% by weight.

2. Clay fraction (0.005 millimeters or smaller) greater than or equal to 25% by weight

3. Liquid Limit $\geq$30%

   Plasticity Limit $\geq$15%

   per ASTM D-4318-00

4. Maximum percentage of gravel by weight 10% (retained on No. 4 US Sieve Size)

1.3.1.2 Topsoil.

Topsoil must conform to the requirements in Article 1081.05 of the Illinois Department of Transportation "Standard Specifications for Road and Bridge Construction" January 1, 2002 edition. If said topsoil on-site do not meet these requirements, approved topsoil meeting these requirements will have to be imported from off-site.

1.3.2 Unsatisfactory Materials

Materials which do not comply with the requirements for satisfactory materials are unsatisfactory. Unsatisfactory materials also include man-made fills; trash; refuse; backfills from previous construction; and material classified as satisfactory which contains root and other organic matter of frozen material. The Engineer shall be notified of any contaminated materials.

1.4 SUBMITTALS

The approval of the Engineer, Robinson Engineering, Ltd. is required for the following:

SD-04 Product Data

Testing
Borrow Site Testing

Within 24 hours of conclusion of physical tests, 3 copies of test results, including calibration curves

and results of calibration tests. Results of testing at the borrow site for compacted clay liner fill.

SD-05 Certificates

Testing

Qualifications of the commercial testing laboratory or Contractor's testing facilities

PART 2 EXECUTION

2.1 OFF-SITE CLAY BORROW APPROVAL

One (1) month prior to pond construction, clay borrow obtained by the Contractor from an offsite source to be utilized as a natural compacted clay liner for both the CCL scheme for the detention pond (option #1) or the composite GCL/CCL (geosynthetic clay liner/compacted clay liner for the detention pond (option #2) scheme must be tested in the laboratory by the Geotechnical Engineer to determine if said clay borrow conforms to the criteria of satisfactory materials as provided in Paragraph 1.3 of this Section. If the clay soil from the offsite borrow meets the 4 criteria (percent finer than #200 sieve, LL, PL and maximum of 10% weight retained on the No. 4 sieve) given in paragraph 1.3.1.1 of this section, then the clay must be tested for permeability (ASTM D 5084-00) for at least 3 remolded compacted clay samples by the Geotechnical Engineer for both compaction percentages of 90% of the maximum dry density as given by the Modified Proctor Test ASTM D 1557-02 and 95% of the maximum dry density as given by Modified Proctor Test ASTM D 1557-02 to determine if the said compaction on this clay soil achieves the required hydraulic conductivity, K, of $1x10^{-7}$ cm/s or less required for natural compacted clay liner for the detention pond to ensure that storm water does not mix with the underlying groundwater.

2.1.1 Minimum Percent Compaction of the Natural Imported Clay Liner.

The minimum percent compaction of the imported natural clay liner will be the lower of the 90% to 95% compaction (per ASTM D 1557-02) that meets the satisfactory materials soil requirements and permeability test (ASTM 5084-00) requirements given in paragraph 2.1 of this section.

2.1.1.1 Natural Imported Compacted Clay Along Pond/Structure Interface

In order to prevent the proposed detention pond against infiltration of water through separation voids caused by potential dessication of soils along the compacted clay liner (CCL)/structure interfaces inside the detention pond, the edges of the compacted clay liner that are located against proposed structures (manholes, grated inlets, storm water lift station walls, and valve vault walls inside the slurry wall should have approved compacted silty clay fill (meeting the requirements for the compacted clay liner (CCL) in this Section) placed in 8 inch loose lifts and compacted with a portable hand pushed tamper in a trench along the structures that is to be two feet wide (from the existing structure) by a minimum of 1 foot deep from the bottom of the 20 inch compacted clay liner (CCL). The minimum compaction requirement for this said compacted clay is given in this Section and is the same as for the compacted clay liner (CCL). (See project plans)

2.1.1.2 Compacted Clay Liner Against Slurry Wall Exterior

A compacted clay liner (CCL) shall consist of approximately 32 inches of approved compacted silty clay fill (meeting the requirements for the compacted clay liner (CCL) in this Section) and shall be placed in 8 inch loose lifts and compacted with a portable hand pushed tamper in a trench along the exterior of the slurry wall that is to be two feet wide (from the

existing outside of the slurry wall). The minimum compaction requirement for the compacted clay outside the slurry wall is given in this Section and is the same as for the compacted clay liner (CCL). The trench is to be approximately 36 inches (3 feet) below the proposed grade and the approved compacted clay shall fill shall consist of the bottom 32 inches of the trench. The remaining upper 4 inches of the trench shall consist of approved topsoil (according to the specification and in this Section) and shall be placed and compacted according to the Specifications in this Section for topsoil. (See project plans)

2.1.2 Minimum Compaction of the Topsoil Layer

The topsoil layer shall be compacted to a minimum of 85% of the maximum dry density as determined by the Standard Proctor Test (ASTM D 698-00).

2.1.3 Placement of Compacted Clay Liner and Compacted Topsoil Layer.

Each lift of compacted clay liner or topsoil shall be placed in approximate 8" loose lifts with each lift compacted by a sheepsfoot compactor to the minimum compaction requirements given in this Section.

2.1.4 Seeding

After placement and compaction of the topsoil layer, the detention pond bottom and side slopes should be Class 1 hydroseeded per section 250 of IDOT's "Standard Specifications for Road and Bridge Construction" January 1, 2002 edition.

2.1.5 Cost of Geotechnical Testing

All cost of the geotech testing of off-site compacted clay for the CCL and the approved topsoil layer will be paid for by the Engineer to SEECO Consultants Inc, Geotech Engineer.

3.1 ONSITE GEOTECHNICAL ENGINEER

The Engineer is required to hire the Geotechnical Engineer, SEECO Consultants, Inc., to provide inspection of the entire compacted clay liner (CCL) construction and all areas of compacted materials. Whether for the imported natural compacted clay pond liner (Option #1 on Project Plans) or for the composite geosynthetic clay liner/natural clay pond liner (GCL/CCL) (Option #2 on Project Plans).

Field density tests using a Troxler nuclear density gauge on each compacted 1 foot thick interval of compacted clay liner and all compacted clay materials and all other compacted materials placed and compacted as given in the project specifications and as shown on the plans must be performed by the field geotechnical engineer along with density and moisture tests results. Also, daily observations of the compacted clay liner (CCL) construction for pond liner Option #1 or Option #2 and compacted clay along the outside of the slurry trench and along compacted clay liner/structure interfaces and compacted clay around pipes within the 10 feet inside and outside from the middle of the slurry wall (see Section 02262A paragraph 3.6.1) will be noted on daily field reports for the entire construction of these compacted clay materials. All Daily Field reports will be copied and sent to the Engineer (Robinson Engineering Ltd.)

SECTION 02376A
GEOSYNTHETIC CLAY LINER (GCL)

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GEOSYNTHETIC CLAY LINER (GCL)

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D 1505	(1998e1) Density of Plastics by the Density-Gradient Technique
ASTM D 5199	(2001) Measuring Nominal Thickness of Geosynthetics
ASTM D 5261	(1992; R 1996) Measuring Mass Per Unit Area of Geotextiles
ASTM D 5887	(1999) Measurement of Index Flux Through Saturated Geosynthetic Clay Liner Specimens Using a Flexible Wall Permeameter
ASTM D 5888	1995; R 2002e1) Storage and Handling of Geosynthetic Clay Liners
ASTM D 5889	(1997) Quality Control of Geosynthetic Clay Liners
ASTM D 5890	2002) Swell Index of Clay Mineral Component of Geosynthetic Clay Liners
ASTM D 5891	2002) Fluid Loss of Clay Component of Geosynthetic Clay Liners
ASTM D 5993	(1999) Measuring Mass Per Unit of Geosynthetic Clay Liners
ASTM D 5994	1998) Measuring Core Thickness of Textured Geomembrane
ASTM D 6072	(1996; R 2002) Obtaining Samples of Geosynthetic Clay Liners
ASTM D 6496	(2003) Determining Average Bonding Peel Strength Between the Top and Bottom Layers of Needle-Punched Geosynthetic Clay Liners

ASTM D 6768	(2003) Tensile Strength of Geosynthetic Clay Liners
ASTM D 792	(2000) Density and Specific Gravity (Relative Density) of Plastics by Displacement
ASTM D 698	(2000) Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ftlbf/ft^3)

1.2 UNIT PRICES

Measurement will be made of the total surface area covered by GCL in square feet as shown on the contract drawings. Final quantities will be based on as-built conditions. Allowance will be made for GCL in anchor and drainage trenches; however, no allowance will be made for waste, overlap, repairs, or materials used for the convenience of the Contractor. This work shall be paid at the contract unit price per SQUARE FOOT for GEOSYNTHETIC CLAY LAYER.

1.3 SUBMITTALS

Approval from Robinson Engineering, Ltd., the Engineer, is required for submittals with a "R" designation; submittals not having a "R" designation are for Contractor Quality Control approval.

SD-02 Shop Drawings

Layout and Detail Drawings; R,

GCL panel layout and penetration detail drawings, as specified.

SD-03 Product Data

GCL Properties

Manufacturer's certified raw and roll material data sheets. If needle punching or stitch bonding is used in construction of GCL, the certification shall indicate that the GCL has been continuously inspected for broken needles using an in-line metal detector and all broken needles have been removed. The certified data sheets shall be attested to by a person having legal authority to bind the GCL manufacturing company. Certified test results shall be submitted at least 14 working days prior to delivery of the GCL.

The Owner and Engineer shall provide a third party inspector for construction quality assurance (CQA) of the GCL installation. The inspector shall be a company who is independent from the manufacturer and installer, who shall be responsible for monitoring and documenting activities related to the CQA of the GCL, throughout installation.

Warranty

Manufacturer's warranty statement.

Tests, Inspections, and Verifications

Manufacturer's quality control (QC) manual which describes testing procedures, frequency of testing and acceptance/rejection criteria for QC testing at least 14 days prior to delivery of the GCL.

Qualifications; R

Manufacturer's and installer's qualification statements including resumes of key personnel involved in this project.

SD-04 Samples

Samples

QC samples at the specified frequencies.

SD-06 Test Reports

Tests, Inspections, and Verifications

Conformance Tests

Independent QC laboratory test results including description of equipment and test methods.

Subsoil Preparation

Certificate of subsoil inspection.

1.4 QUALIFICATIONS

1.4.1 Manufacturer

Geosynthetic clay liner shall be the product of a GCL Manufacturer who has produced the proposed GCL using the same bentonite geosynthetic clay liner for at least 5 completed projects and shall have produced a minimum of 2,000,000 square feet of the proposed GCL.

1.4.2 Installer

The installer shall have installed GCL at a minimum of 5 projects of comparable scope and complexity and shall have installed a minimum of 2,000,000 square feet of the proposed GCL.

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery

Delivery, storage, and handling of GCL shall be in accordance with ASTM D 5888. The Engineer shall be present during unloading of the GCL. Rolls shall be packaged in an opaque, waterproof, protective covering and wrapped around a central core. Tears in the packaging shall be repaired to restore a waterproof protective barrier around the GCL. Unloading of rolls from the delivery vehicles shall be done in a manner that prevents damage to the GCL and its packaging.

1.5.2 Storage

Field storage shall be in flat dry areas where water cannot accumulate and the GCL rolls can be protected from damage. Storage of the rolls on blocks or pallets will not be allowed unless the GCL rolls are fully supported as approved by the Engineer. Stacks of GCL rolls shall be no greater than three high. Rolls shall be covered with a water proof tarpaulin or plastic sheet if stored outdoors.

1.5.3 Handling

During handling, rolls shall not be dragged, lifted by one end, dropped to the ground, or otherwise damaged. A pipe or solid bar of sufficient strength to support the full weight of the roll without significant bending shall be used for all unloading and handling activities. If recommended by the manufacturer, a sling handling method utilizing appropriate loading straps may be used.

1.6 WARRANTY

The manufacturer's warranty shall state that the GCL materials meet all requirements of the contract documents and that for the intended use, the GCL is warranted for 5 years against deterioration.

1.7 LAYOUT AND DETAIL DRAWINGS

The Contractor shall submit GCL panel layout and detail drawings, for approval, a minimum of 14 days prior to deployment.

PART 2 PRODUCTS

2.1 GCL PROPERTIES

A. The GCLs shall consist of a layer of natural sodium bentonite clay encapsulated between two geotextiles and shall comply with all of the criteria listed in this Section. Prior to using an alternate GCL, the Contractor must furnish independent test results demonstrating that the proposed alternate material meets all requirements of this specification. The Contractor also must obtain prior approval of the alternative GCL by the Engineer.

B. Reinforced GCL must be used on slopes as designated by the Engineer. Unreinforced GCL may be used on slopes not exceeding 10H:1V.

2.2 Materials

A. Acceptable reinforced GCL products are Bentomat CL, as manufactured by CETCO, 1500 West Shure Drive, Arlington Heights, Illinois 60004 USA (847-392-5800), or an engineer-approved equal. Acceptable unreinforced GCL products are Claymax 600CL as manufactured by CETCO, or engineer-approved equal.

B. Sloped areas requiring reinforced GCL will be furnished with Bentomat CL (or equivalent). Flat areas of the project requiring unreinforced GCL will be furnished with Claymax 600CL (or equivalent). The placement of all GCLs will be within the proposed soil bentonite slurry wall shown on the project plans and details. The delineation of these areas requiring reinforced GCL and unreinforced GCL are shown on the project plans.

C. The reinforced GCL and its components shall have the properties shown in Table 1. The unreinforced GCL and its components shall have the properties shown in Table 2.

D. The laminated GCL shall have multi-axial tension testing data per ASTM D5617. The GCL shall achieve a minimum multi-axial strain of 9.49%.

E. The minimum acceptable dimensions of full-size GCL panels shall be 150 feet in length. Short rolls (those manufactured to a length greater than 70 feet but less than a full-length roll) may

be supplied at a rate no greater than 3 per truckload or 3 rolls every 36,000 square feet of GCL, whichever is less.

F. A 6-inch overlap guideline shall be imprinted on both edges of the upper geotextile component of the GCL as a means for providing quality assurance of the overlap dimension. Lines shall be printed in easily visible, non-toxic ink.

2.3 Product Quality Documentation

The GCL manufacturer shall provide the Contractor or other designated party with manufacturing QA/QC certifications for each shipment of GCL. The certifications shall be signed by a responsible party employed by the GCL manufacturer and shall include:

A. Certificates of analysis for the bentonite clay used in GCL production demonstrating compliance with the parameters swell index and fluid loss shown in Tables 1 (reinforced GCL for sloped areas) and 2 (unreinforced GCL for flat areas).

B. Manufacturer's test data for finished GCL product(s) of bentonite mass/area, GCL tensile strength and GCL peel strength (reinforced only) demonstrating compliance with the index parameters shown in Tables 1 and 2.

C. GCL lot and roll numbers supplied for the project (with corresponding shipping information).